

IX. *Life Histories in the Hepialid Group of Lepidoptera, with Description of one New Species, and Notes on Imaginal Structure.* By AMBROSE QUAIL, F.E.S.

[Read June 6th, 1900.]

PLATES V and VI.

IN the following paper I have given the result of my special work for the past two or three years, on the Hepialid group of Lepidoptera. It comprises a complete life history of *Porina cervinata*, Walk., a contribution to the life histories of *P. umbraculata*, Gn., and *Charagia virescens*, Dbld., a description of one new species, and notes on imaginal structure in several species.

1. Life history of *Porina cervinata*, Walk., of New Zealand—

Ovæ: deposited	Oct. 21, 1899,	hatched	Nov. 19, 1899 = 29	days.
„	Oct. 25, 1899,	„	Nov. 24, 1899 = 30	„
„	Dec. 10, 1899,	„	Jan. 1, 1900 = 22	„
„	Jan. 28, 1900,	„	Feb. 18, 1900 = 21	„

Ovæ deposited on succeeding nights by the same females, larvæ hatch out on succeeding days, sometimes extending to one week; the above dates are the first day deposited and the first day of hatching. Sequence in colour change is cream when laid, then drab (grey), and finally black in less than ten hours. They are smooth and polished and opaque from the time they are laid to the time of emergence. It is seldom the ovæ form a complete circular outline.

Larva newly hatched. (Pl. V, figs. 11, 12, 13, 14.)

Head is pale brown, rest of larva creamy white. Head exceptionally large, fully the length of any two other segments, whole larva fairly robust. Each lobe has about twelve hairs, nine of which form a margin round the lobe. Ocelli large, mahogany coloured. Antennæ terminated by three slender processes. Suture of lobes and clypeus is very distinct; on each side of clypeus are three hairs, equidistant and almost parallel with sutures; in front of

clypeus are two hairs. Outer palpi of maxillæ terminated by a long slender joint; inner palpus terminates with two very slender separate processes. Mandibles serrate. Labium, at either side has a small slender organ (palpus?) towards apex, and is terminated by the spinneret.

Viewed laterally the prothoracic dorsum is deeply striate transversely; outline of scutellum is indefinite; on dorsal anterior edge there is a transverse series of hairs. Two tubercles (each with one hair) are above the locality of the spiracle, which is large on the posterior area of segment near the probable edge of scutellum; immediately above the spiracle is a tubercle. Above the legs on a lateral swelling are two remote hairs. The meso- and meta-thoracic segments have no dorsal plate, the anterior and post trapezoidal tubercles are normal with those of the abdominal segments; below the trapezoidals four tubercles (one hair each) are alternately anterior and posterior. There are six tubercles on either side of the meso- and meta-thoracic segments. The thoracic legs have hairs at or above the joints. The segmental area of prothorax and all other segments is covered with a dense coat of minute hairs, which are most numerous on the dorsum; they are all over the thoracic segments, but seem to be only dorsal on the abdominal segments. I examined many batches of newly hatched larvæ of this species, and this growth of minute hairs was always present. The larvæ of some broods appear to be more robust than others; in some the prothoracic spiracle was more distinct than in others, of one or two specimens I got a good view of the thoracic intersegmental membrane, and amongst the minute hairs were three rather larger hairs, subdorsal remote and separate, probably homologous with the intersegmental subdorsal tubercles of more adult larvæ.

All the tubercles of the abdominal segments have a single seta, except the supraspiracular tubercle, which has two setæ. The anterior trapezoidal tubercles are dorsal and close, the post trapezoidal tubercles dorsal and remote. The two supraspiracular setæ rise from a common lateral area,—the small anterior hair is very difficult to distinguish at first—on which are the spiracle in an anterior position below the supraspiracular setæ, and the subspiracular tubercles (two) below the spiracle. Abdominal segments 3, 4, 5, 6 have three separate setæ at the base of

the abdominal feet (prolegs). The tubercles of ninth abdominal segment are six in number (viewed laterally), namely one anterior dorsal, and five on the posterior edge of the segment, arranged one below another, all have only one seta. The anal segment has five setae viewed laterally, but in all ten arranged thus: six above the anal fold, and four below it. Viewed ventrally, at the base of each thoracic leg there is a small hair, and on the inner side of the abdominal feet a corresponding hair, the latter (abdominal feet) are terminated by (apparently) a single row of weak hooks.

The tubercle setae are apparently quite smooth.

Larva 51 days old.

Very slender in proportion to length, which is $\frac{3}{8}$ inch. Pale brown head, dark prothoracic dorsum, pale cream segmental area. The dorsum of prothorax is covered by scutellum, which extends to about the middle of the lateral area. Viewed laterally there is an anterior marginal series of hairs on scutellum, four equidistant and a closer fifth; a second transverse series is central with three equidistant and a fourth inner hair, the basal area of these is not enlarged. Spiracle is large, transverse, posterior; below the spiracle is a large anterior tubercle bearing two remote setae. The pro-meso intersegmental membrane has three single subdorsal hairs. Meso-thorax has anterior trapezoidal tubercles coalesced dorsally, and a posterior dorso-lateral plate enclosing the posterior trapezoidal and three lateral tubercles, which form a marginal series resembling that of the prothoracic scutellum; anterior is a small lateral tubercle with one hair, a lower posterior tubercle with one seta, and a large tubercle with one seta, above the legs. The meso-meta intersegmental membrane has three subdorsal hairs. Meta-thorax has the ante-trapezoidal tubercles separate at the median line, but they are elongate laterally, the post-trapezoidal is normal in position but rather large. Supra-spiracular tubercle very large with two setae, a small anterior lateral tubercle with one hair; a lower tubercle with one seta, a posterior tubercle, and one above the leg, each with one seta.

The abdominal segments have tubercles corresponding with those of the newly hatched larva except on the first abdominal; the subspiracular tubercles are coalesced; on

remaining segments they are separate; and there is an additional tubercle with one seta above the base, and also a fourth hair on the base of the abdominal feet. There is also an additional sublorsal tubercle with one seta on the ninth abdominal segment: this may indicate the morphological character of the two supra-spiracular setæ, viz. really two separate tubercles which have coalesced. The subventral tubercles have two setæ.

Ventrally, the abdominal feet have several rows of rather weak hooks which form a complete terminal margin, the claspers have several rows of weak hooks on inner side only.

The skin is covered with fine hair. The tubercle setæ have minute thorns.

Larva 86 days old.

Not quite so slender, length about $\frac{3}{4}$ inch. I noted the spinneret is long and slender; and that ventrally anterior to each prothoracic leg there is a single hair, which is not duplicated on the meso- and meta-thorax. The distribution of hairs on the ventral surface is, one hair near base of each leg on the posterior margin of the thoracic segments; abdominal segments 1 and 2 correspond, the hairs being inner to the two sub-lateral tubercles. 3, 4, 5, 6 have the hairs on inner side of the abdominal feet. 7-10 have corresponding hairs.

I noted also that the middle and the inner hairs of the second series of the prothoracic scutellum have a large circular black area around the base of each.

Larva 93 days old.

I note the anal segment viewed laterally has one dorsal tubercle, one anterior subdorsal, one posterior subdorsal, above the anal orifice, three similarly situated below the anal orifice, and four setæ on base of claspers, one of which is anterior and above the other three. The terminal hooks of abdominal feet are numerous and form a complete margin, the terminal hooks of claspers are strong on inner margin, but weak posteriorly.

Larva 135 days old. (Pl. V, figs. 14, 15, 16.)

Considerably more robust, length from $\frac{3}{4}$ to 1 inch. The larvæ appear to increase rapidly in length in their early days, and subsequently increase more in bulk, and

slowly in length. Shape is cylindrical, posterior segments slightly smaller than anterior. Prothorax slightly smaller than meso-thorax. Trapezoidal tubercles of eighth abdominal are equidistant, of ninth the anterior are remote, and the posterior close together. The supraspiracular tubercles are on conspicuous lateral swellings.

Head reddish brown; dorsal plates, tubercles, setæ, and spiracles are brown; legs pale brown; segmental area cream colour, varying to oily white; abdominal feet white. I suspect the colour bears some relation to the ecdysis. One larva, having just completed its ecdysis, was entirely cream colour except the hairs, but in the course of a few hours became normal, and the skin oily; the contents of the alimentary canal give a slight greenish tint to all but the last two or three segments.

Larva 195 days old. (Pl. V, fig. 17.)

Length $1\frac{3}{8}$ inches. I figured prothorax showing dark areas at base of the hairs of second series. I observed one larva on the verge of ecdysis, the caput already split; under the microscope the setæ of tubercles of inner skin showed through the outer skin the trapezoidal setæ directed towards each other across dorsum, the long supra-spiracular seta just reached the base of the anterior trapezoidal, the short seta obliquely crossed the long one.

Larva 226 days old. (Pl. V, figs. 18, 19.)

Length about $1\frac{1}{2}$ inches. Larvæ exude a dark fluid when handled, apparently from the mouth; I had not previously observed these larvæ to do so. I examined and figured the abdominal feet. A row of strong hooks turned outward completely encircle the inner edge of a central transverse elongate depression, about six rows of sharp points (or spines) surround the inner row of principal hooks. The claspers have strong hooks on inner side, and numerous small spines, which become weaker towards, and are not present at, the middle of the posterior margin, the outline of which forms a central incision.

Larva 239 days old.

A freshly-cast skin examined under the microscope showed the small secondary hairs on some portions. The rims round base of setæ were transparent, the rest of the skin not being so. Setæ of tubercles smooth.

Larva 320 days old, pupated.

Previous to pupation the meso-thorax became much enlarged dorsally and laterally, but I could perceive no further alteration from previous descriptions.

Pupa. (Figs. 20, 21.)

Length about $1\frac{1}{4}$ inches. Dark straw colour with reddish spines. Lateral aspect: Head small, each succeeding segment gradually wider to 7th abdominal. 8, 9, 10 form a rounded extremity.

Ventral aspect: Eyes prominent, elevated. Antenna short, extending very little beyond base of wing cases. Second pair of legs form margin of wing cases, first pair of legs inner to second, tips of third pair between apices of wing cases. Abdominal segments 2 and 3 are coalesced on the ventral surface, the wing cases extend to anterior edge of same. On 4 and 5, in the position of abdominal feet of larva, are some minute probably inoperative spines. On 7 a strongly developed anterior ridge of spines. 8, 9, 10 are smooth on ventral surface.

Dorsum. Part of head constitutes anterior extremity of pupa. Prothorax small, with anterior margin of hairs corresponding with those of scutellum of larva. Mesothorax very large with wing cases attached, trapezoidals as on larva. Meta-thorax small, terminating laterally with edge of fore-wing cases—which completely cover hind-wing cases at base. Abdominal 1 is so small as to look as though squeezed by meta-thorax and 2nd; the latter has trapezoidals, suprspiracular and subspiracular setæ as on larva, the spiracle is wholly above wing-cases.

Abdominal 4, 5, 6 have also the four abdominal-feet-basal setæ in addition to the trapezoidals, suprspiracular and subspiracular setæ, all of which are well developed; 4, 5, 6 also have the ventral inner setæ.

Abdominal 2 to 6 have spiracles. 7 has only a spiracle scar, and only two setæ in position of larval subventral setæ. 8 has only a spiracle scar and one subventral seta. I cannot identify setæ on 9 and 10.

Abdominal 3 has anterior and posterior dorsal spines, each succeeding segment has three spines extending sublaterally, but strongest on dorsum. 8 has only a few dorsal spines, but very much stronger than those on the other segments: these probably operate in conjunction with the

strong ventral spines of 7. The posterior extremity of pupa has four spines.

Only a small portion of the hind-wing cases show beyond the fore-wing cases at the outer margin.

Duration of pupal stage about 20 days.

Imago described by E. Meyrick in "Trans. New Zealand Institute," vol. xxii, with synonymy. I have found this an exceedingly variable species in respect to colour, markings, and structure of wing scales; in its variability there is enough material for the formation of several species, if only the necessary environmental conditions were to happen. Bearing this in mind, it is interesting to note that Mr. Meyrick says "the fuscous forms are sometimes very similar in colouring to *P. despecta*, but they are distinctly shorter winged, and the compound discal spots appear to be a good persistent character." From material received from South Island, and collected by myself in the North Island, I doubt the specific rank of *P. despecta*. Having obtained ovæ which hatched from a specimen which I believed to be *P. despecta* (larva described "Entom. Record," vol. xi, p. 340, under misprint name *Gorina despecta*), I fail to observe any difference between them and the larvæ of undoubted *Porina cervinata*.

2. Contribution to the life history of *Porina umbraculata*, Gn.—

Ovæ: deposited Dec. 2, 1899, hatched Dec. 27, 1899 = 25 days.

„ Nov. 10, 1899, „ „ 6, 1899 = 26 days.

Spherical, cream when laid, black in a few hours, polished, opaque; indistinguishable from the ovæ of *Porina cervinata*.

Larva newly hatched.

Rather larger and more robust than *P. cervinata*, slightly greenish in colour. I examined several broods, and always found the skin quite smooth, whereas *P. cervinata* has a growth of minute hairs all over the skin; nor could I distinguish on *P. umbraculata* the subdorsal intersegmental thoracic hairs. In all other respects, the head, antennæ, ocelli, maxillæ, labium, palpi, spinneret, the number and position of the thoracic and abdominal tubercles, are identical with those of *P. cervinata*. I

especially noted the identity of the three separate setæ at base of abdominal feet, and the position of the tubercles on 9th and 10th abdominal segments.

Larva 18 days old.

Length $\frac{1}{12}$ inch, very slender in proportion to length. Pale cream colour, head pale brown. As regards the number and position of tubercles on the thoracic and abdominal segments; these correspond with *P. cervinata* at fifty-one days old, except that the subspiracular tubercles of first abdominal segment are not coalesced. It may be worth while to point out that the anterior dorsal tubercles of the meta-thorax are anterior to the supraspiracular tubercle, whereas on the abdominal segments the anterior trapezoidal tubercles are above the supraspiracular in position.

The hooks of the abdominal feet appear to be one strong inner row, and one outer row of minute points (or spines). Four separate hairs at base of abdominal feet. The entire skin is covered with minute pimples, but I cannot detect hairs as on the skin of *P. cervinata*. The tubercle setæ are minutely thorny.

Larva 39 days old.

Length $\frac{1}{2}$ inch. Head pale mahogany brown. Eighth abdominal segment pale, all other segments dark, of a rather greenish shade.

Subspiracular tubercles of first abdominal segment are not coalesced. Cannot detect hairs on the "pimples" which cover the skin. Abdominal feet have a strong inner row of hooks, and several rows of minute spines. Claspers incomplete posterior terminal margin.

Larva 81 days old.

Length $\frac{3}{4}$ inch. Colour dark oily greenish. Coalesced subspiracular tubercles on first abdominal segment. Cannot detect hairs on the "pimples." Claspers incomplete, marginal hooks posterior. Setæ thorny.

Imago labelled *Elhamma signata*, Walk., var. *umbraculata*, Gn., in the British Museum collection. Described by E. Meyrick, "Trans. New Zealand Institute," vol. xxii, with synonymy, as *P. umbraculata*. I am convinced that *P. umbraculata* and *P. signata* are specifically distinct, and have noted a difference in the scale structure of the

wings. The time of appearance of imagines is different, there being a full month's interval. I have a note that in 1899 I obtained ovæ of *P. signata*, but failed to rear the larvæ. In 1900 I obtained a number of female *P. signata*, but none deposited ovæ, whereas I experienced no difficulty in obtaining ovæ from *P. umbraculata*.

3. Contribution to the life history of *Charagia virescens*, Dbl.

Larva about three months old.

I have been unable to obtain the ovæ of very young larvæ; this species lives at least two years—possibly three, but I think the former.

Length $1\frac{1}{6}$ inch. Straw colour, head reddish yellow.

Viewed laterally: Head, with serrated jaws. Spinneret long and fine. Ocelli in two parallel rows of three each. Antennæ, with broad basal joint, narrow second joint, shorter third emitting a bristle and three slender processes.

Prothorax: anterior series of hairs on scutellum, as in *Porina*; a mid-lateral black concavity on scutellum, enclosing three hairs, the middle hair being strongest; below is a single hair on scutellum lateral edge: these represent the second series of hairs on *Porina*. The spiracle is posterior, below the scutellum; an anterior tubercle with two hairs above the legs.

Meso- and meta-thorax: anterior trapezoidals on anterior subsegment. Posterior trapezoidals more remote, single setæ stronger than the setæ of anterior trapezoidals, on principal subsegment; below, but on same swollen area, are two setæ, and posterior to the lowest is a small tubercle with one hair, these approximate to the anterior series of prothoracic scutellum; also a small tubercle with one hair anterior to the principal subsegment, above the legs are an anterior and posterior swelling with one seta each, and two setæ above base of legs. Intersegmental membranes of thorax have one subdorsal hair. The thoracic legs have hairs at or above the joints.

This specimen had a remarkable abnormal tubercle on one side only of the first abdominal segment, this had two perfectly formed anterior trapezoidals each with one seta, situate one below the other; on the opposite side of the larva the anterior trapezoidal tubercle was normal, with one seta; posterior trapezoidals normal in position,

with one seta located on small posterior subsegment. Below the antetrapezoidal the supraspiracular tubercle has one long, one short, seta. The spiracle is below the supraspiracular tubercle—not on *edge* of intersegmental membrane as in adult larva; posterior to the spiracle are remote subspiracular setæ; below spiracle is an anterior swelling with one seta; a subventral swelling with two setæ. Abdominal 2 as 1 without the abnormal anterior trapezoidal tubercle. 3, 4, 5, 6 have four hairs at base of abdominal feet. 7, 8 as 2. 9 has two dorsal tubercles, two subdorsal each with one seta, but the seta of one subdorsal tubercle is long, that of the other is short. On posterior edge of 9 are two lateral tubercles with one seta each, and a subventral tubercle with two setæ.

Abdominal feet have terminal hooks incomplete on outer side, otherwise as in adult. Claspers have terminal hooks only on inner side.

Tubercle hairs have minute thorns. Skin covered with minute pimples not so distinct as on *P. umbraculata*.

Figs. 13 and 14, Pl. V, are from a larva, probably half-grown, described in a paper published in "Proc. Roy. Soc. Queensland," vol. xv, with illustrations; length $1\frac{1}{4}$ inches. A second larva about half-grown, length $\frac{7}{8}$ inch, differs only in the colour being rather yellowish than red; I suspect the colour of the larvæ assimilates to the colour of sap-wood in which they live. I note the smaller specimen has spiracles distinctly on segment. I could not discover subdorsal intersegmental thoracic hairs. Black concavity of scutellum has two hairs, one very slender.

Adult larva, length $2\frac{5}{8}$ inches.

Subspiracular tubercles of first abdominal segment are not coalesced. Supraspiracular tubercles have one long, one short setæ. Spiracles are on anterior edge of segments if not actually on the intersegmental membrane. Tubercles of abdominal 9 as before described. Abdominal feet have two rows of terminal hooks which form a complete margin, stems of first row of hooks almost reach second row. Claspers have terminal hooks on inner side only.

Black concavity of prothoracic scutellum has one hair only. Tubercle setæ smooth.

Most larvæ have tubercles with definite area round the base of seta, but none of the larvæ of *C. virescens* have

definite tubercle base, only occasionally a slight discoloured area round seta indicates the tubercle base, I have therefore used the general term swelling rather than tubercle in my descriptions of the species.

I have made notes on the pupa elsewhere. Imagines described by E. Meyrick, "Trans. New Zealand Institute," vol. xxii, with synonymy. It is the only species of *Charagia* in New Zealand.

4. My friend Mr. H. E. Bacot in 1899 sent me a parcel of *Hepialidæ* from S. Africa about one hundred specimens, comprising three or four species, at least one of which so far as I can learn is unnamed. For the purpose of this paper it is necessary to describe and name this species; the British Museum collection contains two other species of the genus awaiting description.

Gorgopis bacotii, sp. nov. (Pl. V, fig. 1.)

♂ 25 mm. Head greyish brown above, dark brown beneath. Thorax grey. Abdomen pale brown. Antennæ ferruginous, segments securiform. Legs of normal size, dark brown above, grey beneath. Fore-wings: a characteristic white band from base along lower side of cubitus to middle, curves from cubitus to apex of wing; area above the band is pale brown, greyish costal streak, brown line on extreme costal margin; below the band is edged with brown, the lower and outer area of wing greyish. Cilia brownish edged with grey. Hind-wings: concolorous pale brown, cilia as on fore-wings.

FLORIDA; SOUTH AFRICA.

Common. Markings constant, no variation in my series of eleven specimens.

5. Probably the genus *Hepialus* preserve among them more extensively than any other genus of the group, the structural character of primitive *Hepialidæ*, at least in the imago. It seems anomalous, however, that the present distribution of *Hepialus*—and subgenera—is so extensive and connected, ranging throughout Europe, Asia, Australasia, North and South America, but not in Africa; and yet species of more specialised genera are isolated and disconnected in distribution. *Porina* (*Elhamma*, Walk.), essentially an Australasian genus, has one representative—*P. niphadius*, Meyr.—in Patagonia; *Leto*, Hubn., a genus

with only two species: *L. staceyi*, Scott, in Australia, and *L. venus*, Cram., in S. Africa; the reverse might be expected, namely, ancient genera disconnected, specialised genera (recent!) connected distribution. If entomologists able to do so would assist with material, I should be glad to work out these seeming anomalies by similar observations to those contained in my notes.

I take this opportunity of thanking those entomologists who already have kindly supplied me with material, especially Messrs. E. Anderson; G. Lyell, junr., of Victoria; R. Illidge of Queensland, and my friend Mr. Arthur Bacot of London, whose help has been invaluable to me.‡

Notes on Ova.

Ovæ of European *Hepialus* are white, or nearly so, and afterwards bluish-black.

Ovæ of New Zealand *Porina* are cream when laid and afterwards black.

Ovæ of Australian *Charagia* are "pale yellow," and afterwards "slatey grey" (Illidge).

There is a colour difference between ovæ of *Hepialus* and of *Charagia*.

Notes on Larvæ.

The study of the habits of the larvæ is very difficult, as they are all either subterranean or internal wood feeders; it is probably due to this that very little is known about them. The Australian genera *Porina*, Walk., *Pictus*, Walk., *Oncopora*, Walk., *Hectomanes*, Meyr., *Trictena*, Meyr., are subterranean, *Charagia*, Walk., are internal wood feeders. Indian and Ceylonese genera: *Hepialiscus*, Hampson, subterranean, *Plussus*, Walk., internal wood feeders.

The newly-hatched larvæ of the genus *Porina* do not eat the empty egg-shell; they always attach a silk thread to the surface on which they walk, and by which they are able to drop as well as a geometrid larva. When young the larvæ are to be found just beneath the surface of the earth, about the base of grass stems; when older they burrow into the ground, constructing a frail "tube," the particles of earth being held together by silk. The "tubes" open at the surface of the ground—I have repeatedly tested this, by pulling up a piece of turf and looking through it—in no case have I observed a cover at the

entrance of the "tube." The length varies to about six inches, and they are either vertical, oblique, or curved; obstacles probably determine the shape of the "tube," which is practically of the same circumference as the larva; a large cavity is constructed at the lower end (*P. cervinata*), within which the larva can curl up comfortably. I have never observed the larvæ feeding, but believe the pabulum to be green stuff above surface, not roots; I have removed green stuff (grass, etc.) as far as two inches below the surface from inside the "tube." I am inclined to think that during wet weather these larvæ are often drowned; on one occasion I found several larvæ killed by a white fungus, which formed a complete shroud round the dead larva.

The larva of *Hepialus lupulinus*, Linné, constructs a "long vertical tube" ("Entom. Record," vol. iii, p. 124) like our New Zealand *Porinas*; this probably feeds above the surface; other *Hepialus*, however, are root feeders. I remember having dug roots of dock with numerous larvæ (*H. humuli*) sticking into them.

Charagia live in the wood of living trees. The burrows are commenced at an upward inclination and then vertically downward (*C. virescens*); the entrance is invariably covered by an operculum of silk—*Zenuzera* is an interesting parallel. Before pupation, the larva constructs a trap-door at the top of the vertical burrow—the only parallel known to me is the hinged covers of the trap-door spiders. Mr. R. Illidge, in his paper on the life history of the timber moths ("Proc. Roy. Soc. Queensland," vol. xiv), believes that the sap constitutes an important item of food; when the wood ceases to live the larvæ die. It may be remarked that the larvæ of *C. virescens* do a great deal of damage to the trees they frequent, not so much individually as collectively; in one extreme case, a section 6 feet long $3\frac{1}{2}$ inches in diameter contained two old empty burrows, six inhabited by nearly full-fed larvæ, two about half-grown, and four small; usually, however, three or four burrows are contained in one tree-trunk. There is the difference in habits between European *Hepialus* (subterranean) and Australasian *Charagia* (wood feeders).

The period of larval existence varies from one to three years in the *Hepialidæ*. It is equally difficult to examine the structural characters of the larvæ in the case of wood feeders; the wood has to be split, at considerable risk

of damage to larvæ. In the case of subterranean borers, though more easily examined, constant disturbance is the cause of great mortality among them. It is impossible to arrive at a knowledge of the number of moults during the larval existence.

It is perhaps unnecessary to note that the three thoracic segments have legs; abdominal segments 3, 4, 5, 6 have abdominal feet (prolegs), the anal segment 10 has claspers, the spiracles are situate on the prothorax, and 1st to 8th abdominal segments.

In newly-hatched larvæ there is a growth of minute hairs over the skin (*Porina cervinata*, fig. 1), and the absence of same (*P. umbraculata*). After the first ecdysis *Porina* and *Charagia* acquire an extra tubercle above the abdominal feet, and four setæ (instead of three) at base of same, and an extra subdorsal tubercle on the ninth abdominal segment. *Porinæ* have enlarged black areas around two separate setæ of the prothoracic scutellum (fig. 8), but *Charagia (virescens)* has three setæ of the second series contained in one enlarged black area. In *Porina* the abdominal feet have several rows of terminal hooks forming a complete margin, the terminal hooks of claspers being similar but incomplete at middle of posterior margin. *Charagia* has two rows of terminal hooks forming complete margin in adult larva, the claspers having two rows only on the inner margin, and the posterior margin being devoid of terminal hooks.

Having no available description of *Hepialus* larvæ, my friend Mr. Arthur Bacot made a description of an adult larva (probably *H. lupulinus*) and a sketch of the position of the tubercles; compared with *Charagia (virescens)* I find a distinct difference. *Hepialus* has the subspiracular tubercles of first abdominal segment coalesced—as in *Porina*; *Hepialus* has three setæ at base of abdominal feet—as in newly-hatched *Porina*; *Hepialus* has a subdorsal tubercle with two setæ on 9th abdominal segment (the suprspiracular in all *Hepialidæ* has two setæ on other abdominal segments), but on the 9th *Porina* and *Charagia* have two separate tubercles each with one hair.

The difference in structure between *Charagia (virescens)* and *Hepialus (lupulinus?)* may be specific only, but in conjunction with colour difference in ova, and the different habits of the larvæ, is interesting, and suggests generic distinction.

Notes on pupæ.

My material is scanty; it comprises empty pupa cases of several species, and live pupa of *Porina cervinata*. In connection with the latter, the complete preservation of setæ in the exact number and position of the larval setæ is most interesting; it is probable that with pupæ of other *Hepialidæ*, the setæ are equally well represented, but during the operation of emergence or from other causes, they get broken, and though some are easily detected, it is usually not possible to detect all the (larval) setæ on empty pupa cases.

The antennal cases are always short, and are not fused to the pupal integument, so that on dehiscence they separate from it, and become detached with the headpiece from remainder of pupa case, leaving a hollow scar at the upper part of each of the second pair of legs. The tips of the third pair of legs are always between the apices of the wing cases. Only a small portion of the outer margin of hind-wing case projects beyond the fore-wing case in *Porina (cervinata)*, fig. 21); a longer portion but no perceptible base, in *Charagia (virescens)*; base to half outer margin in *Trictena (labyrinthica)*; base to costal side of apices of fore-wings in *Phassus (purpurescens)*.

The 1st abdominal segment is represented by a small dorsal area without spiracles, 2 has spiracles wholly above edge of wing-cases—except in *Phassus*, where it is partly covered by the extended margin of hind-wing cases. 1st and 2nd abdominal segments have anterior spines in *Charagia*, but not in *Porina*, *Trictena*, *Phassus*; 3 to 6 have anterior and posterior ridges with spines commencing in the locality of the spiracles and extending across the dorsum; 4, 5, 6 have ventral spines in position of abdominal feet of larvæ (4, 5 only in *Porina*); 7 is the most characteristic pupal segment, in *Porina* a ventral anterior ridge of spines is strongly developed; *Trictena* has the ventral anterior ridge strongly developed, and also spines extending completely round the segmental ridge; *Charagia* and *Phassus* are similar to each other, both have weak posterior spines, and stronger spines in position of abdominal feet (as on 4, 5, 6), these are connected midventrally by a series of spines posterior to the inner (leg) setæ, in *Phassus*, but not so in *Charagia*; 8, 9, 10 are smooth or nearly so in *Porina*, *Charagia*, *Phassus*; 7, 8, 9 in *Trictena* are deeply

scored and pitted over the dorsal and subdorsal area of segments.

In *Hepialidæ* 3 to 7 are free segments, and probably 8 in the female pupa.

Notes on Wing Neuration of Imagines. (Pl. V, figs. 2, 3.)

Hepialid neuration may be written thus :

subcostal	radial	media	cubital	anal	
1	5	3	2	1	= Fore-wing.
1	5	3	2	3	= Hind-wing.

There are some transverse connections at the base of certain nervures, but only one feature in the neuration appears to have any phylogenetic value, it is the relative position of the radial nervules.

The *Trictena* pattern has radial 2, 3, forked from a common stem which rises from the nervure below 4, *i. e.* nearer base of the wing, the transverse cell connection is above the point of separation of 4, 5 radial nervules. *Hepialus* (Europe), *Charagia* (Australia), *Phassus* (Asia), *Gorgopsis* (Africa) are of this pattern, which is further modified in *Hectomanes* (Australia) and *Palpiphorus* (Asia) by the point of separation of 4, 5 radial nervules being above the "cell" vein, *i. e.* nearer the outer margin of wing.

The *Porina* pattern has radial nervules 2, 3, 4 forked from a common stem which rises from the nervure below the "cell" vein. *Hepialiscus* (India) is of this pattern. Other modifications are found in each pattern, thus the subcostal and radial nervule 1 are with difficulty distinguished as separate nervures, especially on the hind-wings, where they have the appearance of complete coalescence, but may be distinctly separated after careful examination with a compound microscope; *Charagia* and *Porina* are each modified in this respect. *Hepialus humuli*, *Sthenopsis argenteo-maculatus* and *Cibyra sylvinus* have three anal nervures in hind-wings. *Hepialus lupulinus* has one (? two) anal nervure. *Charagia virescens* two. *Gorgopsis libania* two. *G. bacotii* two, one of which appears to be fading out. *Hepialiscus* has three anal nervures. *Porina* has two. I regard the decadence of the anal nervules of hind-wings in *Hepialidæ* as of doubtful phylogenetic value. It is probable that the *Hepialiscus-Porina* pattern of wing neuration is modified from the *Hepialus-Trictena* pattern, but not possible that the latter

has modified from the former, it is as nearly certain as anything of the sort can be that the *Hepialus-Trietena* wing neuration is a generalised pattern, from which the wing pattern of *Hectomanes*, *Palpiphorus*, and of *Hepialiscus*, and *Porina*, have been derived.

Notes on Scale Structure of Imagines.

The thorax, appendages, base of wings, and abdomen are covered with hair in the *Hepialidæ*; towards and at the margin of the wings are definite wing scales. I have observed no appreciable difference between the wing scales of ♂ and ♀ of any species. The direction of scales is naturally from base of wing to margin, tip of one scale covering base of next. Wing scales of any given shape may vary somewhat in length or width in different individuals of the same species, irrespective of colour. Side by side on the wing of same specimen, scales may be observed, exactly the same in size and shape, some dark some paler; preponderance of dark scales produces dark specimens and *vice versâ*.

Specific distinction appears in the pattern of the upper surface scales of fore-wings, the scales of the under surface frequently agree with those of the upper, but when differing always have a less specialised shape.

(Pl. VI, figs. A 1—7.) *Porina fuscomaculata* has rather long hairlike scales on the surface of fore and hind wings (Fig. A 6). *P. umbraculata* has short pointed surface scales (Fig. A 1). *P. signata* which resembles the former in markings has two patterns—short broad base (Fig. A 2), uniform short wide scale (Fig. A 3). I could not trace either of these on any specimen of *P. umbraculata*. *P. cervinata* is a variable N. Z. species, and four patterns of surface scales have been observed—as *P. umbraculata* and *P. signata*, and sometimes a short wide scale (Fig. A 4). The surface scales of the hind-wings of *P. umbraculata*, *P. signata*, and *P. cervinata* are more hairlike and longer than the surface scales of the fore-wings, resembling those of *P. fuscomaculata* (Fig. A 6). Fringe scales can be traced from base to outer margin gradually less and less hairlike, they become definite fringe scales at the outer margin, and comprise in *Porina* two patterns in each of the species mentioned—a wide tip long scale (Fig. A 7) forms an outer fringe, a shorter scale of more uniform width (Fig. A 5) forms an inner fringe, both however rise

from the edge of wing membrane; on the hind-wings fringe scale 7 is less wide at the tip and shorter.

These are the only wing scales I have been able to determine in the genus *Porina*; all are finely striate longitudinally, none are dentate in the slightest degree. I do not hesitate to believe the surface scale of *P. fuscomaculata* (Fig. A 6) is the most generalised—distinct from hairs—in the *Hepialidæ*.

Wing scales are modified hairs.

(Pl. VI, figs. B 1—6.) In the *Charagia* group several species are green, some have white spots (*C. virescens*), others silvery metallic spots (*C. eximia*, *C. ramsegi*); the scales of which they are composed are more specialised than the true surface scales, the silvery scales being finely striate, and an effect is produced similar to that of "watered" ribbon. The true surface scales of *C. virescens* are short and rounded on fore-wings (Fig. B 1), longer pointed scales on hind-wings (Fig. B 2) not dissimilar to but wider than the surface scale of *Porina fuscomaculata*. The fringe scales of *C. virescens* fore and hind-wings are of one pattern, short and broad (Fig. B 5), *C. eximia* agrees with *C. virescens*. *C. ramsegi* has an additional fringe scale longer (and forming an outer fringe) than the *virescens* scale which forms an inner fringe. *C. daphnandræ* has dark coloured spots, the green surface scales are longer, and this species has longer fringe scales. *C. lignivorus* has only partly green fore-wings, surface scales and fringe scales as in *virescens*, and also a longer fringe scale almost identical to *Porina* fringe scale (Fig. A 7).

I observed some wing scales of worn specimens having been damaged, a false dentation was produced in relation to the striation; a worn specimen of *C. eximia* had some fringe scales with sharp angular corners (Fig. B 6), and some surface were damaged in a similar manner (Fig. B 4); the dentation of these scales was dissimilar, and examination of a fresh specimen showed no such dentation of wing scales. A worn specimen of *C. lignivorus* had some damaged surface scales deceptively dentate (Fig. B 3).

Wing scales of *Charagia* are striate longitudinally without dentation. Fringe scales appear to be modified surface scales in the *Hepialidæ*.

(Pl. VI, figs. C 2, 3.) *Trictena labyrinthica* is an interesting species, surface scales uniform elongate, but varying

somewhat in shape at tip, some being round (Fig. C 2); fringe scales are remarkably similar to the short fringe scales of *Charagia* (Fig. C 3), but I have not observed in *Charagia* the sloping tip.

Phassus purpureseens has "pear-shaped" surface scales, also longer surface scales similar to *Charagia* (Fig. A 7), fringe scales of *Porina* pattern (Fig. A 7). The prominent fore-legs of *P. purpureseens* are covered with hair, not scales. Wing scales in *Trictena* and *Phassus* are striate longitudinally, not dentate.

(Pl. VI, figs. C 1, etc.) *Hepialus (Sthenopis) argentomaculatus* of America has surface scales identical with *Porina* (Fig. A 4) and with *Charagia* (Fig. B 1), the fringe scales are less wide at the tip than in *Porina* (Fig. A 7). *H. humuli* has "pear-shaped" surface scales (Fig. C 1) also noticed in *Phassus*, some have a small blunt point at the tip but no dentation; the fringe scales are attenuated, apparently dentate; all my specimens being captured I am doubtful as to the dentation of the fringe scales, though I believe it to be true dentation; some short attenuated surface scales have similar doubtful dentation. *Hepialus lupulinus* has all the wing scales dentate and almost identical with *Gorgopis* surface scales and *Gorgopis* fringe scales. *H. hectus*, *H. vellada*, and *Hepialus* (s. g. *Cibyra*) *sylvinus* have surface and fringe scales similar in shape and dentation to *H. lupulinus*.

Wing scales of *Hepialus* are striate longitudinally, some generalised scales without dentation, and specialised scales with dentation.

Hectomanes simulans has surface scales which vary in size, but are all the same shape on fore and hind-wings, slightly dentate at the tips (Fig. D 1), the fringe scales are more noticeably dentate and prolonged to a point at each side of tip; like the fringe scales of *Porina* these have long stem and wide tip. In *H. polypspila* the surface scales are of two patterns, one having a wide base with long neck and slight dentation; this varies in length and width; the other a more uniform, "cigar-shaped," scale, dentate at tip. Fringe scales attenuated but similar to those of *H. simulans*. *H. fusca* has "cigar-shaped" surface scales, and fringe scales not quite so wide at tip as those of *H. simulans*. *Hectomanes* wing scales are finely striate and slightly dentate.

(Pl. VI, figs. E 1—3.) *Gorgopis bacotii* has strongly

dentate surface scales (Figs. E 1, 2) and fringe scales wide at tip strongly dentate, long stem (Fig. E 3). *G. libanica* has very densely scaled wings and remarkably long thick fringes, the surface scales are numerous, some very small some large and wide (Figs. E 4—8), all are dentate; fringe scales are very long, the wide tip being split into long teeth, some of which are as long as the smaller surface scales; side by side in the same fringe are scales of the same shape but variable in dentation, having four, five, or six teeth; the number of teeth in scale dentation is not a reliable character, I have noticed this in other Lepidoptera, notably *Lysiphragma*.

Frenate Lepidoptera usually if not invariably have most of the wing scales dentate, and the thorax, appendages and abdomen covered with scales—not hair—similar to if not identical with the surface scales of the wings; this is so in *Sphinx*, *Acronycta*, *Catocala*, *Herbula*, *Adela*, *Gracillaria*, *Incurvaria*, *Eppippiphora*, and many other genera; among others *Gnophria rubricollis* have rounded abdominal scales, in this respect differing from the wing scales.

These observations attempt to show the evolution of scales from hairs, the specialisation of the scales in *Hepialidæ*, and probable complete displacement of hairs in the Lepidoptera Frenatæ.

Notes on Antennæ of Imagines. (Pl. V, figs. 4, 5, 6, 7, 8, 8a, 9, 9a.)

The segments of the antennæ appear to have definite functions; the basal segment termed the scape—*Hepialus humuli*—is the largest and probably the muscular base of antenna; the second segment termed the pedicel is smaller, probably the nervous base of antenna; the remainder termed clavola, are very much alike, except the two post pedicel segments which are very small, and the terminal segment which is elongate and rounded at the tip. Variation of the scape and pedicel is dependent upon the changes of the clavola (*Bodine*); and specialisation in the *Hepialidæ* is by appendage (pectination) parallel at least to any observed among Lepidoptera Frenatæ.

Probably the least specialised form is that of *Hepialus* and *Charagia*, in which the segments of the clavola are without extended appendages, and are uniformly covered with fine hair, with a few subventral and ventral "sense" hairs—prominent bristles always extended in an anterior

direction. It is more than a coincidence that *Hepialidæ* with this form of antennæ, the males especially, have the third pair of legs reduced—*Hepialus humuli*, *vellada*, *argenteo-maculatus*, or aborted—*Charagia virescens*, *lignivorus*, *eximia*, *ramsegi*, *daphnandra*, and the tibia provided with a conspicuous tuft of hair which is probably a sexual, possibly a scent organ; the bladderlike hind tibiæ of *Hepialus hectus* seem to be the latter. *Hepialus lupulinus* is an interesting species with normal legs, otherwise, so far as my material goes, specialisation of the tibiæ of hind-legs is co-existent with simple antennæ. *Hepialidæ* with specialised antennæ have normal legs.

The clavolar segments of *Gorgopis bacotii* are most interesting, the transverse projection on one side of the shaft, appropriately securiform, is covered with fine hair, but I cannot detect sense hairs (Fig. 5); *G. bacotii* is very different from *G. libania*, which has the shaft attenuated and a prolonged appendage at either side; on the dorsal surface are stout sense hairs which apparently touch the appendage of next segment; there is no ventral appendage.

Hepialus (Cibyra) sylvinus has a robust clavolar shaft with dorsal "sense hairs" and lateral appendage at either side, short, comparatively thick, without "sense hairs." *Hectomanes* have very similar antennæ, they have no ventral appendage (Figs. 8, 8a).

Porina cervinata, *umbraeulata* and *signata*, have elevated anterior edge, semipectinate laterally, and a posterior ventral hump; these appendages are hairy, the shaft has sense hairs (Fig. 6). I examined a living specimen of *P. cervinata* under a compound microscope, and in whatever direction it moved its antennæ, the "sense hairs" remained stationary on the segments. *P. fuscocomaculata* has attenuated shaft to the clavolar segments, bi-lateral appendages hairy, "sense hairs" on the shaft and appendages, and also a hairy ventral hump (Fig. 7).

Trictena labyrinthica has a very specialised form of clavolar segment, the lateral appendages are prolonged, hairy and with "sense hairs," between them a long hairy ventral appendage; the clavolar segments have therefore three appendages strongly developed (Figs. 9, 9a).

PRESENT DISTRIBUTION OF THE HEPALIDÆ—LEPIDOPTERA JUGATE.

Species	Palearctic region					Ethiopian region	Nearctic region	Neotropical region
	Australian region	Oriental region	Asia	Europe	Enurops			
Hepialus, Fabr.	13		Altai, Amur, Kukuinor	All Europe			Guatemala	
" s. g. Clavicorn, Walk.	9					Hudson's Bay to California		
" s. g. Phymatopus, Wallgr.	11			Europe				
" s. g. Stenopsis, Pack.	5					North America	Brazil	
" s. g. Chytra, Walk.	6			Europe			Guatemala to Chili	
Dalaca, Walk.	9	New Hebrides, Ruradonga		Corfu, Asia Min.		Mexico		
Queopeta, Walk.	3	Victoria, Tassmania						
Trictena, Meyr.	1	Australia, Tas.						
Pielus, Walk.	4	Australia, Tas.						
Leto, Hubn.	2	N. S. W., Qsld.			South Africa			
Elwanina, Walk. (Porina)	17	N. S. W., Qsld, Vic., N. Z.					Patagonia	
Perissoclis, Meyr.	3	N. S. W., Vic., S. A.						
Fraus, Walk. (Dactomanes)	6	Tas., Qsld., Vic., S. A.						
Phassus, Walk.	20		India, Ceylon, Burma, Perak, Borneo	Japan, China		Mexico	South America	
Gen. nov.	3						Brazil	
Hepialiscus Hampson	1		India, Nepal, Sikkim					
Palpiphorus Hampson	5		Sikkim, Darjiling	Japan				
Gorgopis, Hubn.	5				Natal, Transvaal			
Gen. nov.	2				South Africa			

Based on list compiled from collection British Museum, by A. Bocol, 1899; with additions and corrections from other sources, by A. Quail, 1900.